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MALARIA IN NORTH CAROLINA.

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The following is a report on the work done under orders directing me to make a survey of the prevalence of malaria in certain districts in North Carolina and to advise with the health authorities of that State regarding the means to be taken for its control.

It was my intention to begin the work by going to Raleigh and consulting with the secretary of the State board of health both as to the itinerary I should follow and the general scope and nature of the work to be done, thus getting the benefit of his knowledge of the local conditions and needs of the State and how best to proceed. As the secretary of the board was absent on business connected with his office, this was impossible, and I was forced to proceed without him until August 23, when I was able to see him in Raleigh. Here the remainder of my itinerary was rearranged in accordance with his suggestion. He went with me to Greenville and we together investigated the malarial conditions at that place.

Acting Asst. Surg. John C. Rodman, United States Public Health Service, joined me at Elizabeth City, the first place visited, and remained with me during the entire trip. His services were invaluable, as he knew and was on friendly terms with physicians in every town we visited—in some towns, all of them. Next to Dr. Rankin himself, I know no one in North Carolina who would have added more to the success of the trip.

I visited Elizabeth City, Hertford, Edenton, Plymouth, Washington, Greenville, Newbern, Goldsboro, Fayetteville, Smithfield, Tarboro, and Roanoke Rapids.

The general plan of work at each of these places was to see the health officials, the superintendent of health of the county and the health officer of the town, if there was one, and with them to make a general rough malaria survey of the town and its immediate environment. This survey was made in a vehicle, with occasional trips on foot, the more carefully to examine probable breeding places for Anopheles and to demonstrate their larvæ in situ to the local health officials, showing them (1) in what kind of places such larvæ were and were not to be found, (2) how to distinguish them from the larvæ of other mosquitoes, (3) how to secure them. This survey was made fairly complete and all places likely to breed Anopheles were taken cognizance of. It was, however, open to a considerable source of error, depending on the rainfall and weather, for I could show the larvæ only in places that were breeding them at the time. For instance, Goldsboro was examined after an extremely dry spell, and numbers of low places were absolutely dry, which almost certainly were breeding places in ordinary weather. Tarboro was first seen 72 hours after a very severe storm, and the ditches and pools which had doubtless contained larvæ were washed out clean. Washington was visited during a period of very high tides, which had let the top minnows into many ditches and pools generally free from them, and so filled the marshes and diluted, so to speak, the Anopheles larvæ that they were not found, or were found in only small numbers, in many places where I am sure they were breeding freely at ordinary seasons. The tides here were fresh water. However, I was always able, except at Selma, to find the larvæ in situ and to show the health officer in what kind of places they were to be found.

Before, in the intervals of, and after this survey I saw the physicians of the town, generally all of them, and got their statements as to the prevalence of malarial fever and its character, both at present and in former years. Their views on the general problems of malarial fever were obtained and discussed. During the survey, if the health officer was with me, as was the case in all but one town, I pointed out the appropriate remedy for each place breeding Anopheles: Draining, tile or open ditch, as appeared applicable, filling, oiling, and poisoning with waste of mills. I also made recommendations for cleaning off brush and weeds where needed.

After the completion of all this work, the night before leaving the town, an exposition of the condition of the town as regards malarial fevers with recommendations for the remedying of such conditions as required remedy was made. This was in the form of a public lecture, beginning with such an exposition of the general subject of malarial fevers, especially their etiology, conveyance, and natural history, as would enable the audience to understand what was said about the problem of their own town. It ended with stereopticon pictures of a few different kinds of mosquitoes and methods of anti-Anopheles work. Anopheles larvæ, home-grown, were also shown at this time and contrasted with Culex larvæ in the same receptacles, so that the difference could be readily seen. I will say that I found no physician, or indeed anyone else, in any place I visited who had seen, or seeing had recognized, the Anopheles larvæ. This knowledge at least is now widespread in the eastern part of the State. The larvæ were generally left with the health officer, so that he might see that they developed into Anopheles mosquitoes. These lectures were, with one exception, well attended, and from the number and character of the questions asked I think the audience was generally interested in and understood them.

The object was not only to acquire information of the condition of the town by this survey but to show the health officer everything I could, so as to increase his efficiency and above all to incite and direct public opinion so that the health officer might be able to institute and carry out successful antimalarial measures for his town.

Properly speaking, no survey of malarial conditions in the towns visited was made either as to number of cases or variety of parasites. It was rather a survey, and a fairly careful one, of the causes of the malarial conditions that did exist, and especially an attempt to remedy such conditions.

The scope of the lectures varied naturally at different places, and according as my audience was entirely townfolks, or partly from the country, did I lay stress on different measures of prophylaxis suitable to their different environment.

At no place was I able to obtain any definite statistics as to the prevalence of malarial fever there, not even as to its comparative prevalence or its virulence. Each physician had an impression that it was "much" or "little," "less than" or "more than," or "about the same as" the last 5 or 10 years. It was "not very malignant" or "showed many bad cases" in the opinion of different men. I could not determine the number of cases, even approximately, in any community. Last year is agreed to have been an unusually bad year in nearly every place, and the worst season to be from September 1 to October 15.

On one thing, however, all the older practitioners of the tidewater towns are agreed, viz: That malarial fever is far less prevalent and less severe than it was 20 to 30 years ago. This is undoubtedly true. I know it both from the instances cited by them and from what I learned during a trip I took through this section in 1896, when malaria was certainly much worse than it is now. Nor are the reasons far to seek:

(1) *The increased prosperity of the country people.*—The rise in price of cotton, diversified farming, and other changes have greatly added to the prosperity of this part of the State. The farmers (North Carolina is essentially a farming country) live much better than they did; have better food, better houses, and better environment generally. They have cleaned up and drained more land, and it is kept for economic reasons freer from standing water and brush, hence of breeding places and shelter for mosquitoes. Surface wells

have been replaced very generally by driven wells and pumps. Much stress is laid on this latter change by the physicians of this section. That these wells would furnish shelters for mosquitoes is certain. I did not think that Anopheles would breed in them until I found Anopheles larvæ in a well in ordinary use in Tarboro. If Anopheles did breed in such wells, I think it must have been rather exceptional and in small numbers and that the closure of the wells did good, if it was so great a factor in the improvement as is generally believed, in removing a shelter for the adult mosquitoes.

(2) *The lowered price of quinine.*—At the time when malaria was so prevalent that drug sold for $4 to $4.50 per ounce wholesale and was, by poor people, used sparingly. Many "wore their chills out," and it was rarely taken save on a physician's prescription. Now it is from about 25 to 28 cents per ounce and is purchased by the ounce by farmers and administered without waiting for a physician as soon as one has a chill, sometimes doubtless unnecessarily, is taken in larger doses, and is longer continued.

These two factors obtain and are sufficient to account for the diminution of malaria observed within the past 20 to 30 years.

In the absence of statistics I can only say that there is much malaria in eastern North Carolina, mainly of a rather mild type, tertian, but there is some estivo-autumnal. There is some in every town I visited, generally in proportion inversely to its size, but varying, of course, with its environment. There is much more in the country, and of severer type, than in the towns. Indeed a severe type, including much blackwater fever, is reported in several counties and small towns, none of which, however, did I visit. These reports are from practitioners in Plymouth, Washington, Newbern, Goldsboro, and Fayetteville, who practice in the places where the severe type prevails.

As compared with the places in which I have worked in the Tropics this country, in spite of much malaria, has three decided advantages: (1) The flight of Anopheles, namely, the season during which malaria can be contracted, is much shorter; (2) there is, judging from reports of physicians, a less proportion of a severe type, estivo-autumnal; (3) those most exposed to it are indigenous, not newcomers, and hence, especially in the country where it is worst, have acquired a high degree of immunity by previous attacks when adult life is reached.

The first makes a marked difference. The flight of the Anopheles is, I should think, not more than 4 to 4½ months, as compared with 9 on the highlands and 12 on the lowlands on the Isthmus of Panama. Thus there is not only a much shorter time for infection, and hence less infection, but there is a considerable time, 7½ months at least, probably 8½ in most sections, for the people to recover from the effects of this infection.

The second is more especially true of places not in the tidewater region. In days not long gone by there was a large amoun of extremely severe malaria in this section, not less than there was in the Canal Zone, and there is from report not a little now, especially blackwater fever and malaria of the cerebral type, in some rural districts and villages.

For the third, I would say that in most districts in the tidewater region but few people living in the country can attain the age of, say, 30 years, without malarial attacks enough to acquire a high degree of immunity, like the natives on the Isthmus and other malarial localities. Those who did not attain a fair degree of immunity would probably not attain adult age. The prevalence of malaria, then, is most injurious to children, who are, of course, newcomers, during the time they should be getting their growth and education, and it gives them a permanent handicap in life. In many districts at present there is not sufficient protection until immunity is acquired.

No estimate based on deaths reported from malarial fever seems worth making because (1) the rates of death to morbidity vary so widely in different locations, from 1 to 1,000 to 1 to 50, I quote practitioners in different places; (2) in children the death is quite frequently from an intercurrent affection and is reported under that head; and (3) the prevalence of a "continued fever not affected by quinine" which is by some practitioners considered typhoid and by others malarial, and the deaths therefrom would be reported by the latter as malarial fever. It is not the direct mortality caused by malarial fever which is so important. This, except where the severer types prevail, is not great. It is an indirect cause of death much more often. But its morbidity is out of all proportion, compared with most diseases, to its direct mortality, and it is as a cause of inefficiency that it does most harm. As a producer of anemia it ranks below, decidedly below, but next to hookworm. A considerable number, nearly all under 20 or 25 years in some sections, lose some time on account of malarial fever each year and are more or less debilitated after each attack. It is especially severe on children during the time they should be growing and getting their education. At one place I examined the spleens of 10 colored boys, and all were enlarged. At another where malaria was very prevalent, but very mild, looking rather closely over a number of people, on the street Saturday afternoon, in church Sunday, and at school the next day, fully 75 per cent of the young people, girls especially, showed decided anemia. I was told by the health officer that only a small amount of hookworm had been found here, and, as sanitary closets were universal, I would have judged so anyway. Adults in the more malarious sections have doubtless acquired a certain degree of immunity, although in the town last mentioned there was considerable malarial fever among the adults.

Some general remarks may be in place here.

(1) The towns visited in tidewater North Carolina were all on fresh water and all, except Plymouth and Fayetteville, fronted on a large body of water, from one to several miles across with generally clean banks which could not breed mosquitoes. Plymouth lies on the Roanoke River, and I suspect that its banks do breed Anopheles, as they were sloping and covered with growth. In only one place, Newbern where it borders on the Trent, is the land across the water close enough for Anopheles bred there to be a menace to health. Fayetteville is some distance from the Cape Fear River.

(2) All lie on soil the surface of which is porous, some, as Hertford, extremely so, and are quite flat. Unless the rainfall is very heavy the lack of slope seems an advantage, as the soil is so porous that the water is absorbed as it falls. If there be slope enough for it to run, it washes off the top soil and forms rivulets, and then pools, on the subsoil which is less porous.

(3) They are built on fairly dry land, as high as the location allows, with marshes or creeks on, or close to, their outskirts. Those that are large have drainage canals running through them, with sometimes marshes of greater or less extent at the ends of the canals to which they are effluents. These marshes may be within or outside of the corporate limits, but are close enough to residences to infect them. Alien Anopheles are as bad as those denizens of the town.

(4) The canals, and indeed all of the large feeding ditches, are cut with perpendicular sides and wide bottoms, 4 feet or more. The result is that the small stream of water which they usually carry does not cover the bottom, but trickles from side to side among grass and other obstructions and forms pools not connected with the stream. Especially is this true where the banks have caved in. Here the top minnows, one of our most efficient antimosquito agencies in this country, can not get at the larvæ and we have breeding places.

The earth from these ditches and the cleanings for years are thrown out on their banks and have made ridges behind which surface water sometimes collects, forming a double line of small marshes. The banks of these ditches are also usually covered with brush and briars, at once furnishing a shelter for mosquitoes and rendering oiling impossible until the bank is cleared.

(5) Outside of tide water, Greenville, Tarboro and Roanoke Rapids are examples. The soil is much less porous and the rain will not soak in so readily. There is, however, sufficient slope for good drainage into rivulets in ravines which border or intersect the towns. These rivulets, however, are sources of danger, as when they go down after a sharp rain they leave pools standing outside of the small low-water stream left, which pools breed Anopheles. Also, where they run slowly and through grass or brush Anopheles are found. I have

found no top minnows in these rapid little streams, not even in still pools in them. It requires as much work of a different kind to protect some towns in this section as in tidewater regions and some have as much or more malaria. Sometimes there is a large flat area adjacent to such a town, as at Goldsboro, where the drains are sluggish and contain minnows.

(6) Something must be said about the top minnows, which in my opinion are most valuable allies to the sanitarian in his antimalarial campaign. They are found all over tidewater North Carolina, and in myriads. They are not only in every stream of running water, no matter how slowly it runs, but in a large number of pools—big and little—which have no effluent. There are no larvæ found where they can get at them. Unfortunately they do not penetrate thick grass, and the edges of streams harboring this fish will sometimes show larvæ. As illustrating how larvæ may escape these fish, I found at Plymouth two Anopheles nearly full grown above a leaf floating attached to its branch just under the surface of water, the pool being full of minnows. Also pools on the edges of ditches are formed without catching any minnows in them. These breed larvæ. They are not found in very foul water, neither are Anopheles larvæ.

Outside of tidewater these fish are found abundantly in still water, as at Goldsboro in slow-running drainage canals and as at Tarboro in a pond and two collections of water where clay was dug for bricks, which I judge had never had an outlet. How they got in the latter places I can not conceive. In two other such "clay holes" I found none. I have not found them in any rapid stream, as in the "branch," a small stream at Greenville. I found only one at Roanoke Rapids, in the canal; none in any of the little streams running through the town, although there was an abundance of still water at the lower parts of them. These streams carry much water, a flood in time of rains, and empty into the river below the paper mill and one cotton mill, which discharge their refuse into it. Possibly this is the explanation. I have not found them in ponds which contained large fish. It is an error to put fish that grow large, I mean such as will eat the minnows, in ponds and streams as a protection against mosquitoes.

(7) All the towns I visited in the tidewater section, except Plymouth, have a rather wide fringe, from 150 to 300 yards and more, of negro houses between the residences of the whites and the marshes which lie on their outskirts, and I am inclined to think, in spite of the number of carriers among the negroes and the opportunity this gives for infecting the Anopheles, that they, the negroes, are a protection to their white neighbors more distant from the breeding places; that very many Anopheles stop at the nearest blood food

available. This question, of course, has not been worked out, but the mill tenements rarely have such a fringe of negro houses and are reported to have decidedly more malarial fever than other whites in towns so protected, even when about the same distance from the marshes. This disposition of the houses of the races comes from the lower rents of houses next to outskirts, due probably to their being more unhealthful to whites.

This fringe is especially marked in Elizabeth City, Washington, and Newbern, and Edenton on one side, the worst.

(8) In spite of various conditions of rainfall, extreme dryness, heavy rains and a flood, Anopheles were found breeding in every place visited except Selma. Selma was visited within eight hours of the storm of September 3, and I stayed only a few hours. Anopheles were found in considerable or large numbers in every place except Smithfield, where they were scarce for the same reason as at Selma. In general, as many could be collected as one cared to give the time for. They were found in the usual kind of breeding places, too well known to describe. In addition they were found in artificial containers, in one at Hertford and two at Smithfield and in two wells at Tarboro. Also in pools in the open sun and in pools red with iron rust at Roanoke Rapids. In one of the collections at Smithfield I found no algæ; the larvæ were small; one of the wells at Tarboro the same. The latter, however, was hard to examine and may have had some. Those found in unsuitable breeding places at Roanoke Rapids were very small and the eggs may have been washed there or deposited there because there was not other water convenient. There was no other water convenient and there must have been any number of female Anopheles about. I doubt if these larvæ would have developed into imagines.

A number of larvæ were allowed to develop and showed *A. maculapennis* Crucians, and in two places, Newbern and Plymouth, argyritarsis. Culex, of course, were plentiful, and, except tænio-rynchus and pungens, not differentiated. Stegomyia were found only at Edenton and Newbern, and in small number. I am informed that there is a striped day-biting mosquito at Raleigh, which from this description should be Stegomyia, but I saw none the one day I stayed there. It seems improbable.

The recommendations made for antimosquito (Anopheles) work in all sections were along these general lines, varying, of course, in detail for each community according to local conditions:

First remove the brush, weeds, and high grass from all places which may possibly be breeding places for mosquitoes, e. g., marshes, ditch banks, etc. This is to enable us to see the condition underside—i. e., whether they conceal breeding places or no. It is a necessary preparation for all antimosquito work. The same thing should be done all over town, especially near houses, as this cover forms shelters for mosquitoes, which die in the hot sun. Our object is, then, primarily to get rid of the breeding places. To do this we must (*a*) remove water, (*b*) render it unfit for breeding.

(*a*) The first by drainage or filling. If by drainage, use underground drains where possible. Where this is impracticable, on account of the amount of water and expense involved, use open ditches, but cut them with sloping banks, so as not to cave in. Make the bottom as narrow as possible, so as to allow for the stream of water covering all of it to utilize top minnows to the best advantage. Let the upper end be as shallow as will drain efficiently, so as to allow as much slope as possible as the ditch deepens toward the effluent end. In any case, the earth taken out of the ditch must not be allowed to form a ridge on its banks, else surface water will accumulate and make pools and marshes behind it, especially the case at Elizabeth City and Edenton. This earth is, in general, needed for filling in tidewater towns, either close by the ditch or elsewhere. Also in cleaning out the ditch it must be kept at its original grade and not deepened. I have seen many ditches deepened below the grade of the crocks or culverts through which they pass under streets, thus forming water holes and breeding places. Filling is scarce in most tidewater towns unless they can avail themselves of a suction dredge. In some, as Edenton and Elizabeth City, it is fairly abundant. In others, sawdust can be used to advantage, and is so used. It is fairly abundant and light for its bulk. Street sweepings and city trash are available, and even kitchen garbage will do. Indeed, the fouler the marsh and its effluent are made the safer it is from Anopheles. Of course, there are other diseases besides malaria to be guarded against. Filling is a particularly hard problem in towns like Washington and Newbern, and, indeed, for the latter drainage not less so.

(*b*) To render the water which can not be removed unfit for breeding, one naturally turns to coal oil. For this to be used efficiently, however, the water must be fairly free of grass and other growths and should be so collected in ditches or a reasonable number of small or moderate sized pools that all of its surface can be oiled. This is to be done once a week. This interval is fixed for administrative not biological reasons.

Where available, waste from the dye plants of cotton mills was recommended to be turned into ditches and streams. If turned into a marsh it does little good unless the marsh has been drained into an effluent ditch. Even the wash water from negro laundresses, living as they do thickly on the outskirts of towns, is of value in the adjacent ditches. At Edenton and Fayetteville two otherwise difficult ditches have been rendered safe by dye waste and at Washington one by the discharge of gas tar into it. There is a gas plant at Newbern, but the tar is not available. It would be invaluable here.

Under conditions where antimosquito work was impracticable, as in small towns and rural communities, as much was recommended as seemed practicable and individual prophylaxis was advised to supplement or substitute it. This was the use of methods to prevent access of mosquitoes to human beings and to render those to whom they do have access insusceptible or less susceptible to infection. The first was the use of screenings and mosquito bars. There is not much screening done in the farmhouses of North Carolina. Even in towns the screening was not efficient, the mesh was too large, No. 12 and a little No. 14, and the frames were not fitted so as to exclude mosquitoes. The use of mosquito bars in the country, I am told, has greatly increased of late years.

The bars in hotels were not well arranged to keep out mosquitoes. Those I saw in private houses were much better because less elaborate.

To describe the proper method of screening in detail was impossible; a few of its principles should be given. Mosquito bars were simpler.

The second was the use of prophylactic quinine. This was under the above conditions, when efficient antimosquito work is impracticable or will not be practiced or gone into in much detail. Its advantages and the methods and form of administration were described and illustrative instances and statistics given. For rural communities that will not screen efficiently—and this is true of nearly all of these communities in eastern North Carolina—quinine thus used seems to me the only efficient method of antimalarial work available. Thus used rightly, it will be increasingly efficient. Those who are thus protected are much less apt to infect mosquitoes than before; most of them are probably incapable of doing so, and this again lessens the number of cases of malaria in their homes and forms an endless chain of progress, so to speak. Also as malaria lessens prosperity increases from the increase of energy and strength of the people, and with increased prosperity come land better cleared and better drained, better living, and better hygiene generally, especially that against malaria, another endless chain for betterment in antimalarial work.

It is only in this way—by personal prophylaxis leading to antimosquito work—that permanent results can be obtained from it. In spite of it there will always be persons infective to mosquitoes, some even among those who take and are protected by quinine, but a much larger proportion among those who do not. So when these measures are discontinued the original conditions of malaria will prevail. In farming communities of isolated families this would occur more slowly than in villages.

Although the elimination of the mosquito is the method of election in an antimalarial campaign where practicable, yet I believe the **prophylactic use of quinine** is capable of much good. The relation between them is like the difference between having a pure water supply, so made by municipal waterworks, and filtering or boiling one's own water when one has not access to a municipal supply.

To give a brief résumé of this survey in detail:[1]

Elizabeth City.

Elizabeth City, 11,000 or 12,000 people, fronts on a broad tidal river, the Pasquetank, with clean banks to the water's edge, allowing no places for breeding here. The soil is very porous and the surface is flat, although there are three lines of depressions, occupied by drainage canals running through the city—two branches of Poindexter's Creek and the Tiber. Everything was very dry on my arrival, there having been no rain for a long time.

There was no water standing in pools or gutters in the city. Indeed, owing to the flatness and porosity of the surface, no water ever stands in the residence part of the city or anywhere except in and about the drainage canals mentioned and their branches and the small marshes at their heads, and some barrow pits for the railroad near the box factory and electric light plant. Some pools along these canals and one of the barrow pits were breeding Anopheles; the pits close to the station were not. At that time I did not know why. One of these drains was especially called to my attention by the health officer as being very insanitary on account of the discharge into it of the refuse of the dye plant of a hosiery mill. This was unsightly and smelled badly, but I was able to report it absolutely free from larvæ or indeed animal life of any kind and that it was the only drainage canal which was not breeding Anopheles.

The marshes at the upper parts of the other three canals, one of which was close to a mill village, as well as to many houses of negroes and some whites, were breeding Anopheles plentifully, as were some small marshes on their banks which should have drained with them, but did not. For years the dirt from the cleaning out of these drains had been piled on their banks, until a series of small marshes had been formed just outside of these ridges along their edges. Also the banks and many of the small marshes were thickets of brush and briars. The open parts of these drains were full of top minnows and even pools left in them which had no outlet or inlet were breeding no Anopheles that I could find. Some doubtless were in the grass, where the fish could not get them. The small marshes outside of the drains were breeding Anopheles in numbers.

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[1] The populations of towns here given are in accordance with the statements of the health officer and include all in such juxtaposition as to form one sanitary unit even if some be outside of the corporate limits.

The problem of this town is easy: Cut the brush and weeds so as to see where the small marshes lie and to remove shelter for the mosquitoes. Fill up the side marshes by leveling the banks of the drains; drain such as can not be filled up. This drainage can all be done by small tile. Clean out the drains and make underground drainage where possible. Where impossible, on account of expense—I think but few will be so found—cut a ditch with sloping banks and a narrow bottom, so that no pools would form and no banks cave and the top minnows can have access to every part. The barrow pits near the box factory to be drained. This can be easily and cheaply done.

All of the front of the town, the longest side, is on a broad and deep river with clean steep banks. The houses of the employees of the cotton mills are almost the only white residences which are much exposed to malarial infection—no negroes between them and the woods.

Hertford.

Two thousand six hundred people. Flatter than Elizabeth City and ground more porous, shell and sand. Long side of town on broad, deep river, with clean banks. No water standing in town 12 hours after a heavy rain. Anopheles found breeding in abundance in a swamp—Gum Pond—just out of town, and on water front near sawmills. Two small ditches near the outskirts, among negro houses, were also breeding places. A small number of Anopheles were found in a stone basin, with green algæ, in the courthouse square. Many culex were breeding in the catch basins of the gutters. No Anopheles in the catch basins. Very little malaria is in Hertford, and that is mainly near the sawmill breeding place. I went into the country near by. It is not intensely malarious, but a great deal more so than the town. The same character of soil and surface, and the marshy places are far enough apart to build well away from them—say, one-third to one-half a mile—but this has not been done in many cases.

A considerable part of the audience here were country people, and the lecture was especially adapted to their needs. Quinine as a preventive was especially urged and its use for this purpose described in detail. These farmers being unusually prosperous, the principles of house screening were gone into at some length. All breeding places here can be easily and cheaply handled, except the Gum Pond. This is beyond the means of the city at present, but it can be gradually attacked and made less a danger than it is now. It is not very close to the residences of the whites—400 yards, I should say—with a broad fringe of negro houses between.

Edenton.

Five thousand five hundred inhabitants, counting those outside corporate limits. One side of town resting on water about 8 miles across, with steep, clean banks, hence no breeding on that side. Soil porous. Not so flat as at Hertford. A beautiful town, beautifully located.

No breeding places in or very near the main residence part of town. Breeding places on two sides of town on the west in a marsh—very many larvæ; to the north fewer in ditches. To the east, next to the water (which is on the south) is a small place where larvæ were found. A ditch runs through the town diagonally. This was partly open and partly covered; where open it was absolutely free from Anopheles, except in one small pool off to one side. This was due to top minnows, which were innumerable. No grass grew in this ditch. Where it was covered—in the lower part of its course in town—the bank had been raised until there was a considerable morass by the side of the ditch, breeding Anopheles freely; also other places in the east end of the town, near Jail Street and elsewhere.

The cotton-mill village outside corporate limits was exposed to a bad breeding place on one side.

I was informed that malaria was most prevalent in parts of the town adjacent to which I found the breeding places.

The breeding places, except the marsh beyond the west end of town, are easily handled by tile drainage. That near the cotton mills can be treated permanently only by filling and by cleaning off brush and oiling until that is done. The filling is being done by the mill owner as rapidly, I judge, as it can be economically done. At neither Elizabeth City nor Edenton did the superintendent of health go with me on the careful search for breeding places, although at both places they went with me on the preliminary survey. At Edenton I took the city health officer the next day and showed him all of the breeding places in the corporate limits.

Plymouth.

About 2,400 inhabitants. This place has a bad reputation for mosquitoes, but, as is usual, the mosquitoes complained of are not malaria carriers. From description they are *Culex tæniorynchus*. The town lies on the Roanoke River, but is in tidewater North Carolina. It is scattered over a large area and the marshlands jut into it in many spurs. Large drains are common with perpendicular sides and wide at the bottom, in which grass grows and along some of which water trickles, forming eddies and pools. Most of them were completely dry, however. The banks of the river, above the normal river banks, are flat and sloping and covered with a heavy growth of reeds and with lotus—the only place save Washington, N. C., where I ever saw this flower wild—growing down in the river in deeper water.

This place is reported by its health officer as fairly malarious, but congratulates itself as being far less so than the county across the river, Bertie, where the health officer reports malaria of a severe type.

Accompanied by the superintendent of health, I demonstrated Anopheles larvæ in various places and made a complete survey of the town. I found here a number of collections of brown water, with a slight taste of tannin, in which I found no larvæ of either Culex or Anopheles. There were many breeding places, however, elsewhere, especially in the pools in the ditches. In one place about 50 Anopheles larvæ, full grown, and some as pupæ, were found in what was really thin mud, the water having evaporated to the consistency of sirup.

It is not possible for this town to do efficient antimosquito work. The area to be attended to is so large and so difficult that the expense of cleaning up breeding places would be absolutely prohibitive. A number of breeding places in the town can be removed, mainly in the broad ditches, and these and the method of remedying them were pointed out to the health officer. It was recommended to do what was possible with the means at their disposal and to rely on screening, mosquito bars, and prophylactic quinine. Screening is more practicable here than in most places, because the Culex mosquitoes are so bad in the early part of the summer that many houses are screened to protect from their bites. Unfortunately, the screening here—as elsewhere in North Carolina—is mainly No. 12, with No. 14 in a few places. No. 14 painted, is about equal to No. 16 and will exclude Anopheles. Much more stress was laid on the use of quinine as a preventive than on screening or bars. It is of more general applicability in Plymouth and its environs. Almost the only antimosquito work recommended was to cut their ditches with sloping sides and narrow bottoms. There are many top minnows here, but the ditches are so wide at the bottom—4 feet and over—that the water forms pools and stagnates and the fish have not a fair chance. Especially is this true when the bank caves in, as it often does, and grass grows in a part of the ditch bottom.

Washington.

Eight thousand to ten thousand people. A town in good sanitary condition and for this section with little malaria. It is low, the highest point 12 feet above mean tide. Two sides are on Pamlico River. On one side the bank is clean and steep to deep water, allowing no breeding places; on the other the bank for a little way near the railroad station is flat and wet and covered with water plants. Surface soil porous. Jacks Creek forms its lower boundary. One of the branches also bounds it. The other runs through the town and branches into several smaller drains within it. There are marshes and small effluents to Jacks Creek out of the corporate limits, but close enough to houses to infect their inmates. The tar from the gas plant is led into one—the largest—branch of this creek and runs through town and into the main fork and thence into Jacks Creek. No drain carrying this tar showed larvæ of any kind. This was by location a very dangerous drain and difficult to handle otherwise.

On my arrival the marshes were so full of water, owing to a series of high tides, and the water carried so many top minnows that many places which should have been breeding Anopheles showed no larvæ. I found numbers of these minnows in stagnant holes and up in a marsh cut off by grass and a bank from the main ditches, which must have been left there since the spring. This was also true of other places in tidewater North Carolina. A number of Anopheles were found, however, in small pools, just at the corporate limits, unconnected with the ditches, in a hole in town recently dug to get sand and in two places in the street gutters. There were many, too, in isolated pools in the marshes toward the cemetery outside city limits, but close to dwellings.

There is the usual fringe of negro houses for, say, 300 yards next to the marsh side of Washington. This is opposite to the Pamlico River side of town where the bank is clean and free from breeding places. Most of the white residences there are well protected and at some distance from breeding places. There are a number of new houses being built outside of the city limits, toward the cemetery, which are convenient to bad breeding places. These could, however, be readily remedied by tile drainage, as the marshes and their effluent ditches are small. There were the same wide-bottom ditches here as elsewhere in North Carolina. Owing to the high tides the bottoms were all covered.

The mayor and superintendent of health and the people generally seemed much interested in antimosquito work, and a fairly complete system of drainage and filling was advised for this city, but owing to the loss caused by the recent storm I doubt if it can be carried out. Very little filling is required except on one short place along the river front near the railroad station, and this can be easily done. A survey was also made here of a suburb that is in process of building, and advice was given of the work necessary to free it and its environment from Anopheles breeding places.

Greenville.

Six thousand people. The first town I visited not on tidewater. It is an upland town on the Tar River, with good slope and elevation, draining into a "branch" which rises in town and runs around it on one side at some distance therefrom. Soil is not porous, hence water that does not run off stands until it evaporates. Dr. Rankin accompanied me to this town. It was only 18 hours after a heavy rain and the ditches were well washed out; indeed "the branch" into which they empty was still running muddy water and the marshes were overfull. I was able, however, to show him Anopheles larvae, and as the marshes went down we found them in numbers and full grown, from a marsh convenient to the residence portion of town. As an index to the number of female Anopheles there must have been about "the branch" bounding the town, I would say: The branch was out of its usual banks in the morning; that afternoon late and next morning it had gone down and left many pools inside its high banks but outside of its water course. Every one of these pools we examined, and we examined many, showed minute Anopheles larvæ, some a few hours old only. Either the surface of the creek in flood was pretty thickly strewn with Anopheles eggs or else there were females ready to deposit eggs in each of the pools as they formed. The latter is doubtless the explanation. This part of the creek was too distant from habitations to be much of a danger to them. There were no top minnows in the "branch;" hence the multitude of larvæ in the pools. An abundance was found in still water, without effluent, in another part of town, in several places indeed.

The problem of this town is, in the main, very simple. There is plenty of slope and the town is rich and progressive. Drainage underground is practicable for every place except "the branch" and that can be bushed and its pools oiled once a week during the mosquito season—say from June 1 to October 1.

As a number of physicians practicing in the country were present and many farmers as well, it being court week, stress was laid in the lecture on measures applicable to rural conditions, especially on the use of prophylactic quinine.

Newbern.

Sixteen thousand people. This was the largest city visited. When I was here in 1895 it had a bad reputation for malaria. It is on tide water with a maximum elevation, I think, of about 12 feet above the water. Sanitary work has been done here in the way of cleaning and oiling street gutters and ditches, etc., and the surface soil is very porous. There was then no water breeding in the white residence part of town. There were, however, two ugly marshes, Duffy's field and Richardson's marsh, in town. Both of these and a part of the low edge of the town next to the Trent River at Long Dock were breeding Anopheles, the marshes very freely. The water of the Trent River was brown and like that at Plymouth in which no larvæ of any kind were found, only lighter in color. The edges of this river were from other reasons not likely to breed Anopheles, but at any rate none were found in this water. This same water, very dark, was found in a bog of peat in the town and with no larvæ of any kind. The two marshes and the swampy place above the Trent water, at Long Dock, were the only places found breeding Anopheles.

A ditch suitable for breeding them if clean was found close to Duffy's field, but it was so foul from garbage and fecal matter that, although full of Culex, no Anopheles were found. I was glad to show this to the health officer who accompanied me, as showing the effect of foul water.

The statement of the solution of the Newbern problem is easy. Drain or fill the two marshes. The execution is difficult. The marshes are about sea level, or at least river level. They can not be drained. There is no filling available, except garbage and street trash; possibly sawdust can be secured. I recommended that both of them be (1) cleared of bushes, weeds, and tall grass and kept clear of them; (2) ditched with a system of broad, narrow-bottomed ditches and cross ditches, as shallow as possible at the ends and sloping down to a kind of sump at the deepest part of the swamp, so as to drain the marsh into ditches and to collect the water in the ditches into one body; (3) oil the ditches. At the same time to begin filling the marshes, starting at the edges, using everything available for this purpose, including the earth removed from the ditches dug to drain them. It will take some years, I judge, to complete the filling if sawdust is unavailable, unless earth is brought from outside, or mud pumped in from the river. This last, of course, would be easy and not costly if a suction dredge were available, i. e., working in the neighborhood. The officials do not think the town would go to the expense necessary to get such a dredge to come there. There is no other quick way to get permanent results, although sawdust would do if available. The breeding place on the river bank can only be filled. This is a small place, however, and easily handled. It can be filled by getting material from the bank itself, slightly broadening the river.

Goldsboro.

Eight thousand people, a highland town, soil fairly porous, good elevation, very thriving and progressive.

The first day, or half day, I went around with the health officer and found one Anopheles larva. Here I learned to appreciate what

I had observed at several places before—that collections of water close to railroad stations where much switching is done rarely show Anopheles. The sparks that are thrown out of locomotives when they puff fall in such waters in great numbers and each one partially burnt brings a small drop of oil. Whether it is from the frequent agitation of the water or from the oil, certain it is that in this water covered with small pieces of coke I have not found Anopheles larvæ. One finds a few Culex. The water here showed a good film of oil. The next day—Sunday—I went out by myself, walking, and found Anopheles in abundance. I got the health officer that afternoon and showed him the breeding places and caught the larvæ from them in his presence. There were a fair number of breeding places here, but not many close to the white residences. It was exceedingly dry, however, a severe drought, I was told, and I saw a number of places in which water had stood long enough to leave a green deposit on the ground when it evaporated; and long enough to develop Anopheles. A number of new houses for whites are building or are just built in close proximity to bad breeding places across the railroad from the main town.

The solution of the problem here is drainage. Underground drainage is practicable for nearly all of the breeding places, although filling is advisable about the Veneer mill. For this, sawdust is readily available.

Fayetteville.

About 10,000 people. This is on the Cape Fear River. The soil only fairly porous. It has good elevation for the most part and very flat for the remainder. It is more spread out—occupies the largest area—of any town of its size that I know. A great deal of oiling had been done during the summer and fall; more done and more efficiently done than in any place I visited and many promising ditches and pools were bare of Anopheles. As was natural, however, they had oiled only the large places and full ditches, so I had no difficulty in collecting a large number of Anopheles larvæ from a dozen different places. The same condition existed here as at Elizabeth City. There was much complaint of the dye from a silk mill being turned into a drainage canal, fouling it and rendering it a menace to health. This canal and other places contaminated by the dye were absolutely free from mosquito larvæ of any kind. I found top minnows in large number in a marsh which I am reasonably sure had had no outlet for some years. It was probably fed by springs. Where the fish were there were no larvæ; near the edges where there were no fish, larvæ were abundant.

The problem in Fayetteville is difficult from its extent; there is so much ground to cover. I am informed that there are 75 miles of city ditches and canals. It can mainly be met by (1) cutting brush to see what we have under it and to remove mosquito shelters, (2) draining the small ditches and small marshes with tile, and (3) digging the larger ditches into which the small ones open, with sloping sides and narrow bottoms, keeping them free from growth and, unless filled with minnows, oiling them. It is this last that will be the difficulty, because it is work that must be continuously done. We were treated extremely nicely at Fayetteville. The night of the lecture was the night of the great storm, September 3, and yet a very respectable audience of city officials, physicians, and other prominent men were present.

Selma and Smithville.

Selma and Smithville are small towns in Johnston County, about 4 miles apart. These places were reached the morning after the great storm.

Selma is a scattered village of, I judge, 600 or 700 people, close enough to ditches and marshes to be infected from them. No Anopheles were found here; the place was almost flooded, and we remained only a few hours. We went then to Smithfield, a much larger place, with the superintendent of health of Johnston County. This county, which, I am informed by Dr. Rankin, is one of the most progressive in the State, has what is known as a "whole-time" health officer. He devotes all of his time to his official duties.

At Smithfield, getting there quite late and the same conditions of flood existing as at Selma, no search was made for Anopheles. A supply had been brought from Fayetteville to show the health officer, as I anticipated that they could not be found on account of the rain. However, the next day two collections were found, both in artificial containers, by Dr. Rose, of Smithville, to whom I had shown my specimen larvæ and who recognized and brought them to me. One collection was in a wooden tub, sitting under a bush with green algæ growing in it. The other was in a granite-ware pan. It had been oiled before I saw it but I could see no algæ. These larvæ were small, not half grown, some of the others were full grown. Whether the first lot would have come to maturity I do not know. I doubt it.

All probable breeding places were pointed out to the health officer as usual, although there would probably be some on the river banks as the water went down not now visible. This place can be made quite free from Anopheles at very little expense, mainly by covered drains. The lecture here was especially addressed to the farmers from the surrounding country and recommendations were on the same general lines as at Greenville for personal, as distinguished from municipal, prophylaxis, house screening, mosquito bars, and especially prophylactic quinine, which subject was rather fully gone into.

Tarboro.

This is a thriving town and rich, about 6,000 or 7,000 people I should judge. I did not record the population. It is on the Tar River and is the county seat of Edgecombe County, which is one of the best agricultural counties in the State—mainly of large farms. It is in the high land with plenty of elevation. Surface soil not very porous.

This place was reached September 6, three days after the storm. As the weather had been quite cold, I felt doubtful of finding larvæ from eggs deposited since that time and felt sure that the pools and ditches had been swept clean by the flood. The main ditches were running freely and very muddy when I first examined them. The river was out of banks and rising, backed well up into a ravine running from the town.

However, some half-grown Anopheles larvæ were found in the grass on the edge of a ditch and a large number in a disused well in the heart of the town. The water of this well was about 12 feet deep and about 2½ feet below the surface of the ground, its sides covered with green algæ and shaded by bush and a well curb. The larvæ were of all sizes, many full grown, and very abundant. A stroke made at random with a small saucer brought up seven Anopheles larvæ. Anopheles larvæ were found more sparingly in a deeper well 4½ feet below the surface of the ground, which was in daily use. I could make out no algæ on this well, which was simply a terra-cotta pipe about 2 feet in diameter. Seven larvæ were taken from this well, but it was very hard to dip from, and there were doubtless more. None were over half grown and it seemed an unlikely breeding place. Two days later, Monday, in the afternoon, we found any number of very small Anopheles larvæ in every pool or ditch where one could reasonably expect to find them, mainly on or beyond the outskirts of the town. The weather had been very warm these three days. Five or six were taken per stroke where none had been found Saturday morning. Top minnows were found in very large numbers in a pond in the upper part of a ravine running through the town and in two "clay holes"—ponds from which clay had been dug years ago—unconnected with any stream; also in some of the larger ditches. None were found in the ditches scrubbed out, so to speak, by the muddy storm water.

A very careful survey was made of this place and its environments because (1) there were several points in dispute between the health officer and individuals; (2) there were some inherent difficulties of an engineering nature; and (3) the temper of the people was such that I was assured that reasonable recommendations for sanitary improvements would be carried out and I wished to recommend all that was necessary and nothing unnecessary. Unfortunately, although I remained here six days, the river remained too high for me to investigate the condition of the lower part of the ravine it filled or its overflowed banks. I think, however, that the health officer is thoroughly familiar with the principles which should guide him in determining breeding places and the methods of removing them. Also he knows Anopheles larvæ and how to find them, and I am sure he has the support of the town authorities and of the community. Tarboro has not much malaria, except in certain sections of town, and the better class houses are mainly screened and with finer wire—No. 14—than usual in North Carolina.

On Wednesday I met and addressed a meeting of farmers at the experiment station about nine miles distant and on Thursday a convention of women's clubs. From what I heard and from what I saw of the people, the children especially, I judge that Edgecombe County is not specially malarious. As the country people are mainly large farmers, planters in fact, a fairly full exposition was given at these meetings of the advantages of screening in addition to those of mosquito bars and quinine prevention as was usual to rural communities. Many houses in the country in this county are screened.

Roanoke Rapids.

This was the last place visited. It is a small town, I judge of 1,500 people, on the Roanoke River. Close adjacent is Patterson village, with, I presume, 500 or 600 more.

The town is on a series of ridges with water courses in the ravines between. The surface is not very porous. There are no or very few top minnows. It is essentially a mill town, nearly all of the inhabitants being employees of the cotton or paper mills, or their families. The houses are well built, with screens in doors and windows, unfortunately of No. 12 mesh, and not well fitting. Garden and yard to each house. It covers a large territory for its population, and although on ridges but few of the mill tenements are far enough from the small rivulets in the ravines to be beyond the flight of the Anopheles there breeding.

The malaria here is not of bad character; almost exclusively tertian. There is, however, much of it. The physicians so report, and the young people, especially the children in school and on the street, confirm them. It was nine days after the storm, but only three of them had been warm, and I expected to find only young larvæ in the pools and water courses, as they should have been thoroughly washed out at that time. This was true of the upper part of them, and young Anopheles were found in abundance. Lower down, where the stream was sluggish and broadened out in the grass and brush, there were many, very many, large larvæ, full grown, and pupæ. All or nearly all Anopheles. I think larvæ, and possibly eggs, had washed down to the lower part of one ravine and accumulated there, for they were in greater number than I ever saw before. One stroke of a small saucer made at random in a grassy cove showed 24 larvæ and 3 pupæ, all Anopheles, many large but the majority small, and some minute. No top minnows in this reach of water, although it seemed eminently suitable for them. Anopheles larvæ in some stage were found in almost every part of every rivulet and pool examined. Many small ones only, in places in which one would not have expected to find them. The same was true of a small morass and stream in Patterson village and close enough to infect both ridges on which it is built. This marsh had been burnt over some weeks previously by the use of coal oil, and no full-grown larvæ were found in it. None were found in wells, although search was made for them. Culex was found in wells.

The problem of ridding this town of malaria is a difficult one on account of its cost, due to the large area and small number of people. Each ridge of houses has a breeding place close enough to infect—sometimes one on each side. Fortunately the personality of the principal people here promises much. They are energetic and in earnest, and are good business men. I believe that they will rid the place of malaria or reduce it to a minimum. It is proposed (1) to drain and clean the marsh and its effluent next to Patterson village, and then to turn the dye from that mill into its head. This will eliminate this long and dangerous drain. (2) An effort will be made to use the waste from the paper mill to destroy breeding places in its vicinity. The dye from the Roanoke Rapids Cotton Mill may also be thus utilized. (3) Such drains as can not be so treated, it is proposed to put underground in terra cotta or galvanized iron pipes. This will be costly, but the mayor, a young man and an engineer, believes it will be feasible and will pay in increased good health and efficiency of the people. (4) If it be impracticable to cover all of the drains, an effort will be made to stock the lower reaches, where the water lies in still pools, with top minnows, where I think they will thrive, and cover the remainder. The health officer is going to take this matter up this fall with the United States Fish Commission.

I remained over four and one-half days in all at this place, to talk over the plans for its sanitation with the mayor, health officer, and the different mill owners and help them formulate plans for cooperation in this work. They all agreed, and it is unquestionably true, that the lessened loss from sickness and the increased efficiency which will result from eliminating or nearly eliminating malaria here will justify a considerable expense. That the mayor is an engineer, and that the mill owners are business men, used to investing money for the sake of getting returns, makes the prospects good for results here.